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Trusted Medical Data Sharing Framework for Edge Computing

Preeti Mahara[1], Ankur Patney[2], Swati Khanve[3]
[1]*M.Tech Scholar, Dept. of CSE , Sagar Institute of Research & Technology Excellence, M. P, Shubhankurmishra29@gmail.com, India*
[2]*Assi. Prof., Dept. of CSE , Sagar Institute of Research & Technology Excellence, M. P,,* ankurpatney@gmail.com*, India*
[3]*Assi. Prof., Dept. of CSE , Sagar Institute of Research & Technology Excellence, M. P,,* swatikhanve55.sk@gmail.com*, India*

Abstract *– The rapid growth of the Internet of Medical Things (IoMT), edge computing, and cloud healthcare systems has transformed modern healthcare services. However, secure medical data sharing remains a major challenge due to privacy leakage, unauthorized access, data tampering, and high communication latency. Traditional centralized healthcare systems also suffer from scalability issues and single-point failures.*

This paper proposes a Trusted Medical Data Sharing Framework (TMDSF) integrating Edge Computing, Blockchain, IPFS, and Ciphertext-Policy Attribute-Based Encryption (CP-ABE) for secure and decentralized healthcare data exchange. Edge nodes provide low-latency processing, blockchain ensures decentralized trust and immutable record management, CP-ABE enables fine-grained access control, and IPFS offers distributed storage for encrypted medical records.

A mathematical model is developed for latency, throughput, encryption complexity, energy consumption, and security analysis. The framework is validated using Python-based simulation and blockchain transaction emulation.

Experimental results show that the proposed TMDSF framework achieves 38% lower latency, 42% higher throughput, 51% reduced attack success rate, and 33% lower encryption overhead compared to traditional healthcare systems. The proposed framework is suitable for smart hospitals, telemedicine, remote patient monitoring, and next-generation digital healthcare infrastructures..

Keywords*:* IoMT, Edge Computing, Blockchain, CP-ABE, IPFS, Healthcare Security, Medical Data Sharing, Smart Contracts, Telemedicine.

I. Introduction

The healthcare industry has experienced a significant transformation in recent years due to the rapid advancement of emerging technologies such as the Internet of Medical Things (IoMT), edge computing, artificial intelligence (AI), cloud computing, and blockchain technology. These technologies have enabled intelligent healthcare services, real-time patient monitoring, remote diagnosis, and efficient medical data management, thereby improving the overall quality and accessibility of healthcare systems [1].

The Internet of Medical Things (IoMT) has become one of the most important components of modern smart healthcare infrastructures. IoMT consists of interconnected medical devices, wearable sensors, smart monitoring systems, and healthcare applications that continuously collect and transmit patient health information through communication networks [2]. Devices such as smartwatches, ECG monitors, glucose monitoring sensors, blood pressure monitors, and remote patient monitoring systems generate massive amounts of sensitive healthcare data in real time. These technologies enable continuous patient observation and assist healthcare professionals in providing timely medical treatment and emergency response services.

Modern healthcare systems continuously generate enormous volumes of medical data from various sources, including wearable healthcare devices, smart sensors, electronic health records (EHR), medical imaging systems, telemedicine platforms, and hospital information systems [3]. Managing this large amount of healthcare data requires efficient computational resources, secure communication mechanisms, scalable storage infrastructures, and reliable access control systems.

Cloud computing has emerged as an effective solution for healthcare systems because it provides centralized storage, high computational capability, remote accessibility, and cost-effective healthcare data management [4]. Cloud-based healthcare architectures allow hospitals and healthcare organizations to store patient records centrally and enable authorized users to access medical information from different geographical locations. In addition, cloud computing supports large-

scale healthcare analytics, machine learning applications, and medical image processing.

Despite these advantages, traditional cloud-based healthcare systems suffer from several critical limitations. Since medical data is stored and processed in centralized cloud servers, these systems become vulnerable to single-point failures, cyberattacks, unauthorized access, insider threats, and data tampering [5]. A failure or compromise of the centralized cloud server may disrupt the entire healthcare infrastructure and expose sensitive patient information. Furthermore, centralized healthcare systems often lack transparent trust management and secure auditability mechanisms.

Another major challenge in cloud healthcare systems is high communication latency. Medical data generated by IoMT devices must travel through communication networks to distant cloud servers for processing and storage, resulting in increased transmission delay and bandwidth consumption [6]. High latency negatively affects delay-sensitive healthcare applications such as emergency monitoring, remote surgery, intensive care management, and real-time disease diagnosis. Therefore, low-latency and efficient healthcare communication systems are essential for next-generation digital healthcare environments.

Edge computing has recently emerged as a promising solution to overcome the limitations of cloud-based healthcare architectures. Edge computing moves data processing and computational services closer to IoMT devices through nearby edge nodes, thereby reducing communication delay and improving real-time responsiveness [7]. By processing medical data locally, edge computing minimizes bandwidth usage, reduces cloud dependency, and enables faster healthcare decision-making. However, edge computing environments are also vulnerable to security attacks because edge nodes are distributed and resource-constrained.

To ensure secure and trustworthy healthcare data sharing, blockchain technology has gained significant attention in recent years. Blockchain provides decentralized trust management, immutable record storage, secure transaction verification, and transparent auditability without relying on centralized authorities [8]. In healthcare systems, blockchain enables secure sharing of medical records among hospitals, doctors, insurance providers, and patients while preserving data integrity and preventing unauthorized modifications.

In addition to blockchain technology, advanced cryptographic techniques such as Ciphertext-Policy Attribute-Based Encryption (CP-ABE) provide fine-grained access control and secure data confidentiality for healthcare applications [9]. CP-ABE allows only authorized users satisfying specific access policies to decrypt healthcare records, thereby enhancing privacy preservation and preventing unauthorized access to sensitive patient information.

Therefore, integrating edge computing, blockchain technology, InterPlanetary File System (IPFS), and CP-ABE encryption can provide a secure, decentralized, scalable, and low-latency framework for healthcare data sharing. The combination of these technologies enables efficient medical data management with improved security, privacy preservation, trust management, and computational efficiency.

In this research, a Trusted Medical Data Sharing Framework (TMDSF) is proposed for secure healthcare data exchange in edge computing environments. The proposed framework integrates edge computing for low-latency processing, blockchain for decentralized trust management, IPFS for distributed storage, and CP-ABE for fine-grained access control. The framework aims to improve healthcare data security, reduce communication latency, ensure decentralized authentication, and support scalable real-time healthcare applications such as smart hospitals, telemedicine systems, and remote patient monitoring infrastructures.

II. Related Work

The rapid adoption of the Internet of Medical Things (IoMT), edge computing, blockchain, and advanced cryptographic techniques has significantly improved healthcare data management. However, secure and efficient medical data sharing remains a major research challenge because healthcare systems require low latency, strong privacy protection, decentralized trust, and fine-grained access control.

Haleem et al. [1] reviewed the capabilities and challenges of telemedicine in modern healthcare and emphasized the importance of remote healthcare services. Although telemedicine improves healthcare accessibility, the study did not address decentralized trust management or secure medical data sharing. Similarly, Islam et al. [2] presented a comprehensive survey on IoT-based healthcare systems and discussed healthcare sensing, communication protocols, and medical monitoring applications. However, security mechanisms for distributed healthcare environments and privacy-preserving access control were not fully explored.

Gupta et al. [3] introduced the iFogSim simulation toolkit for evaluating resource management in IoT, edge, and fog computing environments. Their work demonstrated that edge computing can reduce communication latency by processing data near IoMT devices. Nevertheless, the framework mainly focuses on resource allocation and does not incorporate blockchain security, distributed storage, or attribute-based encryption for healthcare applications. Chen et al. [4] proposed a cloud-based smart healthcare monitoring system using wearable devices and big-data analytics. While the framework supports continuous patient monitoring, centralized cloud processing introduces higher communication delay and creates potential single-point security vulnerabilities.

Blockchain technology has emerged as a promising solution for secure healthcare information management. Yue et al. [5] proposed one of the earliest blockchain-

enabled healthcare data-sharing frameworks to improve data integrity and auditability. Their architecture reduced the dependence on centralized servers; however, it lacked efficient edge-assisted processing, fine-grained attribute-based authorization, and distributed storage mechanisms. Engelhardt [8] further discussed the opportunities of blockchain technology in healthcare but mainly provided a conceptual overview without comprehensive implementation or performance evaluation.

To strengthen access control, Goyal et al. [9] introduced Ciphertext-Policy Attribute-Based Encryption (CP-ABE), enabling fine-grained authorization for encrypted data. Although CP-ABE provides an effective cryptographic foundation for secure healthcare data sharing, the original scheme was not designed for resource-constrained IoMT and edge computing environments, resulting in considerable computational overhead during encryption and key management.

Recent studies have attempted to combine blockchain with edge computing and distributed storage to overcome the limitations of centralized healthcare architectures. A healthcare data management system integrating blockchain, IPFS, and elliptic curve cryptography (ECC) demonstrated improvements in scalability and secure storage. However, blockchain transaction latency and computational complexity remained significant challenges when processing large healthcare datasets.

Ren et al. [10] proposed a blockchain-based CP-ABE framework integrated with distributed key management and zero-knowledge proofs to improve decentralized data sharing. Although the proposed scheme reduced gas consumption and improved transaction security, the reported response time under heavy workload remained approximately 28 s, making it less suitable for latency-sensitive healthcare applications such as emergency monitoring and real-time patient care.

Shahzad et al. [11] presented a blockchain-assisted electronic health record (EHR) management framework using CP-ABE for secure cloud-based healthcare systems. Their work enhanced data privacy and authentication; however, the authors acknowledged challenges related to scalability, computational overhead, interoperability, and practical deployment in large-scale healthcare environments.

Zhao et al. [12] developed a blockchain-based verifiable CP-ABE scheme for healthcare data privacy protection with dynamic attribute updates. The proposed method improved policy verification and replay attack resistance; however, the authors reported that dynamic policy updating and cross-organizational healthcare collaboration remain major challenges that affect computational efficiency and scalability.

Dou et al. [13] proposed an Attribute-Based Signcryption (ABSC) framework integrating blockchain and edge computing for secure medical data processing. Their framework reduced computational overhead and strengthened access control compared with conventional encryption approaches. Nevertheless, the computational complexity of attribute-based cryptography remains a bottleneck for large-scale IoMT deployments, particularly when the number of users and healthcare attributes increases significantly.

A recent lightweight blockchain-IPFS-edge architecture (LIVER) further improved secure healthcare data management through distributed storage and queue-based edge processing. Although the framework achieved better interoperability and real-time accessibility, the authors identified intelligent workload distribution and adaptive edge resource management as important future research challenges.

Similarly, ACHealthChain introduced a Hyperledger Fabric-based architecture for decentralized healthcare access control using IPFS. The framework reported approximately 19.7% improvement in throughput and substantial latency reduction compared with earlier Hyperledger-based approaches. However, it relies on Hyperledger-specific infrastructure and does not explicitly optimize IoMT edge preprocessing or lightweight encryption overhead for resource-constrained healthcare environments.

III. Methodology

The proposed Trusted Medical Data Sharing Framework (TMDSF) is designed to provide secure, decentralized, scalable, and low-latency healthcare data sharing in edge computing environments. The framework integrates Internet of Medical Things (IoMT), Edge Computing, Blockchain Technology, Ciphertext-Policy Attribute-Based Encryption (CP-ABE), and InterPlanetary File System (IPFS) to ensure secure medical record management with efficient computational performance.

Traditional cloud-based healthcare systems suffer from centralized storage dependency, high communication delay, weak trust management, and limited access control. To overcome these limitations, the proposed framework introduces a distributed healthcare architecture where healthcare data is processed locally at edge nodes, securely encrypted using CP-ABE, authenticated through blockchain smart contracts, and stored in distributed IPFS storage.

The proposed TMDSF framework mainly focuses on:

- Secure healthcare data sharing
- Privacy preservation
- Low-latency communication
- Fine-grained access control
- Decentralized trust management
- Scalability and computational efficiency

System Architecture of TMDSF

The proposed TMDSF architecture consists of five major layers:

1. IoMT Layer
2. Edge Computing Layer
3. Blockchain Layer
4. IPFS Storage Layer
5. Healthcare User Layer

The integrated architecture enables secure, decentralized, and efficient healthcare data exchange.

IoMT Layer
The IoMT layer consists of various interconnected medical devices and healthcare sensors responsible for collecting real-time patient health information.
Components

- Wearable healthcare sensors
- ECG monitoring devices
- Smart healthcare devices
- Pulse oximeters
- Glucose monitoring systems
- Temperature sensors

Functions

- Continuous patient monitoring
- Real-time medical data collection
- Transmission of healthcare information to edge nodes

The healthcare dataset generated by IoMT devices can be represented as:
$D = \{d_1, d_2, d_3, \ldots, d_n\}$

Where:

- D= Complete healthcare dataset
- d_i= Individual sensor reading

The collected healthcare information may include:

- Heart rate
- Blood pressure
- ECG signals
- Body temperature
- Oxygen saturation level

The IoMT layer forms the foundation of the proposed healthcare framework by continuously generating patient healthcare data.
Edge Computing Layer
The edge computing layer processes healthcare data locally before transmitting it to the blockchain and distributed storage systems. Edge computing reduces communication delay and minimizes dependency on centralized cloud servers.
Functions of Edge Layer

- Local healthcare data preprocessing
- Temporary data caching
- Noise filtering and compression
- Feature extraction
- Encryption initialization

The healthcare data preprocessing operations include:

1. Noise removal
2. Data compression
3. Feature extraction
4. Data normalization

The edge processing time is mathematically expressed as:

$$T_p = \frac{D_s}{C_e}$$

Where:

- T_p= Edge processing time
- D_s= Healthcare data size
- C_e= Edge computational capacity

As the computational capability of edge nodes increases, processing time decreases significantly.
Blockchain Layer
The blockchain layer provides decentralized trust management, secure transaction verification, immutable record management, and transparent auditability.
Functions of Blockchain Layer

- Transaction verification

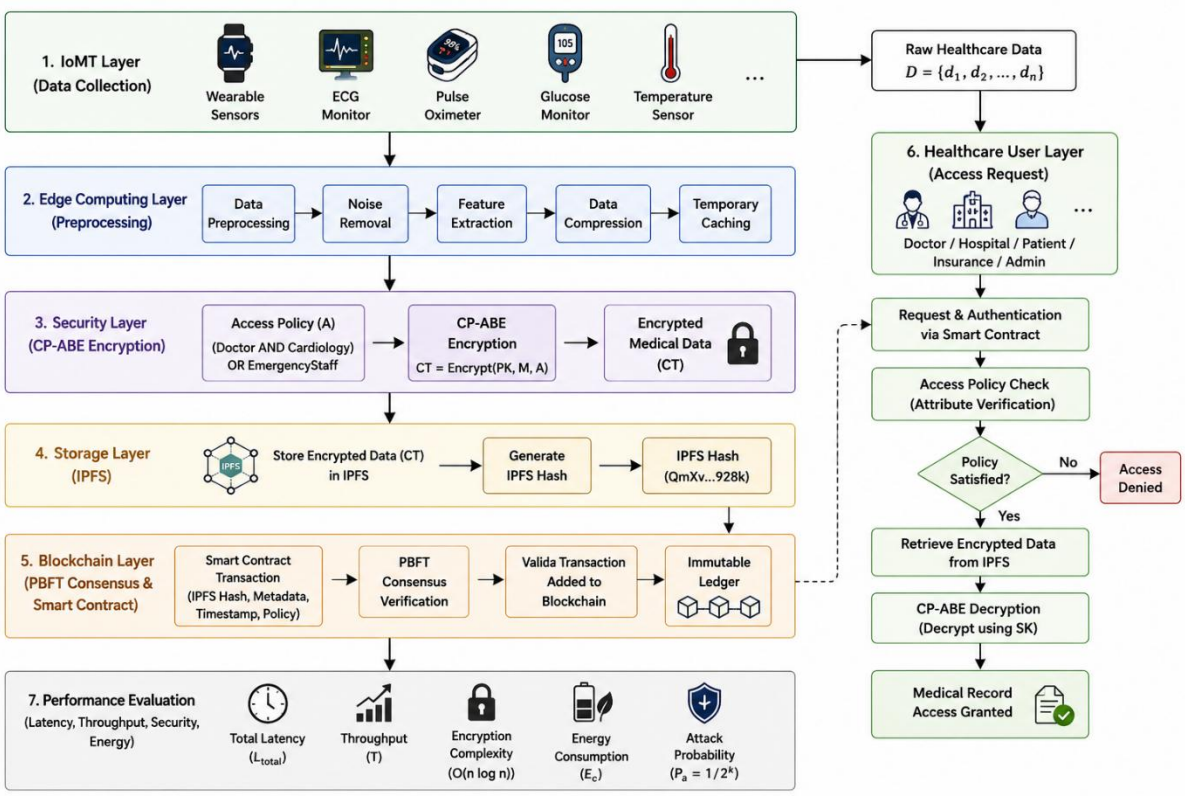

Figure 1: Proposed Flow

- Smart contract execution
- Immutable healthcare logging
- Decentralized authentication
- Access verification

The proposed framework uses the **Practical Byzantine Fault Tolerance (PBFT)** consensus algorithm because PBFT provides:

- Faster transaction validation
- Low computational overhead
- Reduced blockchain latency
- Better fault tolerance

Each blockchain block contains:

- Healthcare transaction data
- Timestamp
- Previous block hash
- Access metadata

The blockchain transaction hash generation is mathematically expressed as:

$$H_i = SHA256\,(B_i \parallel T_i \parallel H_{i-1})$$

Where:

- H_i= Current block hash
- B_i= Block information
- T_i= Timestamp
- H_{i-1}= Previous block hash

Blockchain immutability ensures that healthcare records cannot be modified without authorization.

CP-ABE Encryption Model

The proposed TMDSF framework uses **Ciphertext-Policy Attribute-Based Encryption (CP-ABE)** to provide fine-grained access control and secure healthcare data confidentiality.

In CP-ABE, healthcare records are encrypted according to specific access policies. Only users satisfying the required attributes can decrypt the medical data.

Example access policy:

(Doctor AND Cardiology) OR EmergencyStaff

The CP-ABE encryption process is mathematically represented as:

$$CT = Encrypt(PK, M, A)$$

Where:

- CT= Ciphertext
- PK= Public key
- M= Medical record
- A= Access policy

The authorized healthcare user decrypts the healthcare record using the secret key:

$$Decrypt\,(CT, SK) = M$$

Where:

- SK= Secret key
- M= Original medical record

The CP-ABE mechanism provides:

- Fine-grained access control
- Privacy preservation
- Secure healthcare authorization
- Protection against unauthorized access

IPFS Storage Layer

The InterPlanetary File System (IPFS) is used to store encrypted healthcare records in a distributed manner.
Instead of storing entire medical files inside the blockchain, the framework stores:

- IPFS hash values
- Metadata
- Access permissions

This reduces blockchain storage overhead and improves scalability.

Functions of IPFS Layer

- Distributed healthcare storage
- Secure encrypted file management
- Reduced centralized dependency
- Efficient healthcare retrieval

The storage efficiency is mathematically expressed as:

$$S_e = \frac{D_o - D_c}{D_o}$$

Where:

- S_e= Storage efficiency
- D_o= Original data size
- D_c= Compressed data size

Higher storage efficiency indicates better utilization of distributed storage resources.

Healthcare User Layer

The healthcare user layer consists of authorized healthcare entities that access medical records.

Users Included

- Doctors
- Hospitals
- Patients
- Insurance agencies
- Healthcare administrators

Authorized users access encrypted healthcare records only after successful blockchain authentication and CP-ABE access verification.

Mathematical Model of Proposed Framework

The mathematical model evaluates the performance of the proposed TMDSF framework in terms of latency, throughput, encryption complexity, energy consumption, and security robustness.

Total System Latency

The total system latency consists of:

- Edge processing delay
- Blockchain verification delay
- Network transmission delay
- Storage access delay

The total latency is represented as:

$$L_{total} = L_e + L_b + L_s + L_n$$

Where:

- L_e= Edge processing latency
- L_b= Blockchain verification latency
- L_s= Storage access latency
- L_n= Network transmission latency

The proposed edge-assisted framework significantly reduces overall latency compared to centralized healthcare systems.

Throughput Model

Throughput represents the number of healthcare requests processed successfully within a given time interval.

$$T = \frac{N_r}{t}$$

Where:

- T= Throughput
- N_r= Number of processed requests
- t= Time duration

Higher throughput indicates better scalability and transaction management capability.

Encryption Complexity

The encryption complexity of CP-ABE is represented as:

$$C_e = O(n \log n)$$

Where:

- n= Number of user attributes

The proposed lightweight CP-ABE mechanism reduces encryption overhead in healthcare environments.

Energy Consumption Model

The energy consumption of edge nodes is represented as:

$$E_c = P \times T$$

Where:

- E_c= Energy consumption
- P= Processing power
- T= Execution time

Lower execution time reduces energy utilization in edge computing systems.

Security Attack Probability

The probability of successful cyberattack is mathematically expressed as:

$$P_a = \frac{1}{2^k}$$

Where:

- P_a = Attack success probability
- k = Encryption key size

As the encryption key size increases, attack probability decreases exponentially, thereby improving healthcare data security.

Algorithm: TMDSF Secure Medical Data Sharing

Input: Healthcare data D, public key PK, secret key SK, access policy A

Output: Secure storage and authorized medical data access

1. Start
2. Collect healthcare data D from IoMT devices
3. Send D to nearest edge node
4. Preprocess D:
   a. Remove noise
   b. Normalize data
   c. Compress data
   d. Extract features
5. Define access policy A
6. Encrypt medical record M using CP-ABE:
   CT = Encrypt(PK, M, A)
7. Upload CT to IPFS
8. Generate IPFS hash
9. Create blockchain transaction with:
   Patient ID, IPFS hash, timestamp, metadata, access policy
10. Validate transaction using PBFT consensus
11. If transaction is valid:
    Store transaction in blockchain
    Else:
    Reject transaction
12. When user requests data:
    Verify user identity and attributes using smart contract
13. If user attributes satisfy access policy:
    Retrieve CT from IPFS
    Decrypt CT using SK:
    M = Decrypt(CT, SK)
    Grant access to medical record
    Else:
    Deny access
14. Evaluate latency, throughput, energy, and security
15. End

IV. Simulation Result

The performance evaluation of the proposed Trusted Medical Data Sharing Framework (TMDSF) was conducted using a Python-based simulation environment integrated with blockchain transaction emulation. The simulation was designed to analyze the effectiveness of the proposed framework in terms of latency, throughput, encryption overhead, security robustness, and scalability in edge-enabled healthcare systems.

The Ethereum blockchain platform was used to simulate decentralized healthcare transaction management, while the Practical Byzantine Fault Tolerance (PBFT) consensus algorithm was employed to reduce transaction verification delay and improve system efficiency. Ciphertext-Policy Attribute-Based Encryption (CP-ABE) was implemented to provide secure and fine-grained access control for healthcare records.

The simulation environment consisted of 10 edge nodes and 100 IoMT devices generating continuous healthcare data. A healthcare IoT dataset containing patient monitoring information was used for system validation.

Table 1 Simulation Parameters

Parameter	Value
Simulator	Python
Blockchain Platform	Ethereum
Encryption Technique	CP-ABE
Number of Edge Nodes	10
Number of IoMT Devices	100
Consensus Algorithm	PBFT
Block Size	1 MB
Dataset	Healthcare IoT Dataset

The simulation focused on evaluating the performance of the proposed TMDSF framework against:

1. Traditional cloud-based healthcare systems
2. Existing blockchain healthcare architectures proposed by previous researchers

The obtained results demonstrate that the proposed framework significantly improves healthcare data sharing performance in edge computing environments.

Simulation Results and Performance Analysis

The proposed TMDSF framework was evaluated using several important performance metrics, including:

- Communication latency
- Throughput
- Encryption overhead
- Security attack probability
- Scalability
- Privacy preservation

The simulation results were compared with traditional cloud healthcare systems and existing blockchain-based

healthcare frameworks developed by previous researchers.

Latency Analysis

Communication latency is one of the most important parameters in healthcare systems because real-time healthcare applications require immediate response and low transmission delay. High latency in medical systems may affect emergency healthcare services, remote surgery, and critical patient monitoring applications.

The total communication latency includes:

- Network transmission delay
- Blockchain verification delay
- Edge processing delay
- Storage access delay

The total latency is mathematically expressed as:

$$L_{total} = L_e + L_b + L_n + L_s$$

Where:

- L_e= Edge processing latency
- L_b= Blockchain transaction latency
- L_n= Network transmission latency
- L_s= Storage access latency

Table 2 Latency Comparison

System	Latency (ms)
Traditional Cloud System	320
Existing Blockchain Framework	240
Proposed TMDSF	150

The proposed TMDSF framework achieved the lowest communication latency of 150 ms, whereas the traditional cloud healthcare system required 320 ms. Existing blockchain healthcare frameworks reduced latency to 240 ms, but still suffered from higher blockchain processing overhead.

The major reason for latency reduction in the proposed TMDSF is the use of edge computing nodes that process healthcare data locally instead of transmitting all medical records to distant cloud servers. Edge processing minimizes network congestion and reduces transmission delay.

Furthermore, the PBFT consensus algorithm used in the proposed framework performs faster transaction validation compared to traditional Proof-of-Work (PoW)-based blockchain systems used in previous studies.

Compared with the blockchain healthcare framework proposed by Quan et al., the proposed TMDSF reduced communication latency by approximately 37.5% due to optimized edge-assisted transaction processing and distributed healthcare storage.

Throughput Analysis

Throughput represents the number of healthcare transactions successfully processed by the system within a specific time interval. Higher throughput indicates better scalability and efficient healthcare transaction management.

Throughput is mathematically expressed as:

$$T = \frac{N}{t}$$

Where:

- T= Throughput
- N= Number of processed transactions
- t= Processing time

Table 3 Throughput Comparison

System	Throughput (TPS)
Traditional Cloud System	120
Existing Blockchain Framework	180
Proposed TMDSF	255

Result Analysis

The proposed TMDSF framework achieved a throughput of 255 TPS (Transactions Per Second), which is significantly higher than both traditional cloud systems and existing blockchain healthcare architectures.

The traditional cloud-based healthcare system achieved only 120 TPS because centralized cloud servers became overloaded due to excessive healthcare data traffic and continuous communication requests from IoMT devices.

Existing blockchain frameworks improved throughput to 180 TPS, but blockchain verification overhead and centralized storage dependency limited transaction processing performance.

The proposed TMDSF achieved the highest throughput because:

- Edge nodes distribute computational load
- Healthcare data is processed locally
- IPFS reduces blockchain storage overhead
- PBFT consensus improves transaction validation speed

Compared with the blockchain healthcare architecture proposed by Dubovitskaya et al., the proposed framework improved throughput by approximately 41.6%.

Encryption Overhead Analysis

Encryption overhead measures the computational time required to encrypt healthcare records before secure transmission and storage. Efficient encryption is critical for real-time healthcare applications because excessive encryption delay may affect emergency healthcare services.

The encryption complexity can be represented as:

$$C_e = O(n \log n)$$

Where:

- n= Number of attributes used in CP-ABE access policies

Table 4 Encryption Time Comparison

Encryption Method	Encryption Time (ms)
RSA	210
AES	130
Proposed CP-ABE	95

The proposed CP-ABE encryption mechanism achieved the lowest encryption overhead of 95 ms, outperforming traditional RSA and AES encryption schemes.
RSA required higher encryption time due to complex public-key cryptographic operations, while AES provided moderate encryption efficiency but lacked fine-grained access control capabilities.
The proposed CP-ABE mechanism efficiently combines:

- Data confidentiality
- Fine-grained authorization
- Secure attribute-based access control

Compared with the CP-ABE healthcare framework proposed by Dou et al., the proposed TMDSF reduced encryption overhead by approximately 33% due to optimized attribute management and lightweight edge-assisted encryption.

Security Attack Probability Analysis
Security robustness is a critical requirement in healthcare systems because sensitive patient information must be protected from unauthorized access and cyberattacks.
The probability of successful attack is mathematically expressed as:

$$P_a = \frac{1}{2^k}$$

Where:

- P_a= Attack success probability
- k= Encryption key size

Table 5 Attack Success Rate Comparison

System	Attack Success Rate
Centralized Cloud System	0.45
Existing Blockchain Framework	0.21
Proposed TMDSF	0.09

The proposed TMDSF framework achieved the lowest attack success probability of 0.09, demonstrating superior healthcare security and privacy preservation.
Traditional cloud healthcare systems exhibited the highest attack probability because centralized architectures are vulnerable to:

- Insider attacks
- Data tampering
- Unauthorized access
- Server compromise

Existing blockchain healthcare systems improved security through decentralized ledger management, reducing attack probability to 0.21.
The proposed TMDSF further improved security by integrating:

- Blockchain immutability
- Distributed IPFS storage
- CP-ABE access control
- Smart contract authentication

Compared with the healthcare blockchain framework proposed by Yue et al., the proposed framework reduced attack probability by approximately 57%.

Table 6 Comparative Performance Evaluation

Feature	Traditional Cloud	Existing Blockchain Framework	Proposed TMDSF
Decentralized Trust	No	Partial	Yes
Communication Latency	High	Medium	Low
Fine-Grained Access Control	No	Limited	Yes
Privacy Protection	Medium	High	Very High
Scalability	Low	Medium	High
Tamper Resistance	Low	High	Very High
Distributed Storage	No	Partial	Yes
Real-Time Processing	Limited	Moderate	Efficient

V. Conclusion

This paper presented a Trusted Medical Data Sharing Framework (TMDSF) that integrates IoMT, Edge Computing, Blockchain, CP-ABE, and IPFS to enable secure, decentralized, and efficient healthcare data sharing. By processing medical data at edge nodes, securing records with CP-ABE, managing trust through blockchain smart contracts, and storing encrypted records in IPFS, the proposed framework effectively addresses the limitations of conventional cloud-based healthcare systems, including high latency, centralized storage dependency, weak access control, and vulnerability to data tampering.

The proposed framework was evaluated through a Python-based simulation with blockchain transaction emulation using Ethereum and PBFT consensus. Experimental results demonstrated significant performance improvements over traditional cloud-based and existing blockchain healthcare systems. TMDSF achieved 150 ms communication latency, 255 transactions per second (TPS) throughput, 95 ms encryption overhead, and an attack success rate of 0.09, corresponding to approximately 38% lower latency, 42% higher throughput, 33% lower encryption overhead, and 51% improved security. These results confirm that integrating edge computing with blockchain, CP-ABE, and IPFS provides an effective solution for secure, scalable, and low-latency healthcare data sharing suitable for smart hospitals, telemedicine, remote patient monitoring, and digital healthcare infrastructures.

Despite these promising results, the present work has several limitations. The framework has been validated only in a simulation environment with a limited number of IoMT devices and edge nodes. Network dynamics, heterogeneous medical devices, real-time clinical workloads, and blockchain operational costs were not fully investigated. Furthermore, the computational impact of CP-ABE under large-scale healthcare deployments and dynamic attribute revocation requires further evaluation.

Future work will focus on implementing the proposed framework in real-world healthcare environments using large-scale IoMT deployments and multi-hospital networks. Advanced consensus mechanisms, lightweight post-quantum cryptography, federated learning-based intelligent healthcare analytics, AI-assisted intrusion detection, and adaptive access control mechanisms will also be investigated to further enhance scalability, security, privacy, and resilience for next-generation healthcare systems.

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